"EVOLUTION: A Rational Way to Achene Hybrid Network Implementations"

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Cable Television had it's beginning with an antenna system perched on the highest accessible location and with coaxial cable runs to town residents below. There were few at that time who envisioned this business network would evolve into a multi-media communications system.

Early implementations utilized available cable and electronic equipment to receive and distribute broadcast (off-air) signals to populated areas with poor reception. This quickly evolved into a business opportunity for entrepreneurs who would eventually change American T.V. Both equipment suppliers and cable operators responded to the opportunity at hand providing more sophisticated equipment, cable and services. Soon in-home equipment began to emerge as a complement to installed headend and cable plant electronics. Converters first expanded available channels then were used to decode scrambled signals for pay service security; finally new sophisticated addressable converters were created to provide subscriber specific service authorization under computer control.

The evolution which has occurred in Cable Television distribution systems has been running on a converging course with the Computer and Communications industries. This is evidenced by the myriad of new products and services we see at this 1983 NCTA Show. The triad, Cable/Computers/Communications, opens new revenue producing potential for both entertainment and service related programming; these are the opportunities of the 80's.

## Cable Television: System-Architecture

Since many definitions are appended to today's technical terms the following is our reference for System Architecture:

> "The composite design which results from using physical structure to interconnect with and enable (logical) devices used to perform systems operations." --S. Westall, 1983 NCTA

This reference applies to many device structures in electronics, construction and many other fields. For example, reservoir and water distribution systems employ an architectural design to deliver service to residential and business consumers.

## Traditional Cable TV Networks

The early pioneers in Cable Television utilized a system architecture which satisfied their objectives efficiently and economically; a cable plant which was installed at minimum cost and was extendable. This network implementation was a tree-branch structure and supported cable broadcast services.

The first and second generation cable television systems utilized this structure to build increasingly complex cable operations. Even today this architectural approach remains viable for broadcast services which do not require future sophisticated control or service capabilities.

## Services and Control: Requirements Variables

The evolution occurring in cable television is not driven by new techniques engineered in the many development labs represented here today. Rather, our engineering is driven by emerging revenue producing opportunities available to cable television; to be successful we must respond with cost effective, expandable, production solutions. The design variables seem simple: Services and Control.

## Control

Early systems had little requirement for network control. The physical installation (on the pole) was seen as enough of an impediment to service theft. Quickly we learned the entire country was getting smart in the electronics field and there were many who would tap into the cable plant to pirate service. The industry's problem awareness in this area ultimately resulted in opening the door for computer/communications technologies to be applied in cable television control application; at this juncture cable television networks satisfied the fundamental criteria qualifying them as computer communications systems architectures: The physical and logical functions were separate/discrete network elements; physical facilities fell under logical device control; network electronics were active and functionally interdependent. With this development, system design rules had to be expanded to accomodate computer control; the basic tree-branch guide lines no longer applied.

Services

Initially, cable television services were comprised of off-air signals distributed via a quality carrier. This quickly led to inclusion of FM radio, distant TV stations and finally pay oriented events or services. For over two decades these services have been successfully delivered via tree-branch structures.

During the mid-to-late 70's the computer/communications fields enjoyed an explosive growth in system applications. Software based products were developed to address numerous commercial and service based applications. As previously noted, this growth first crossed into cable television in the system control area. The cable industry also began to recognize the potential these new control capabilities offered. They quickly translated the potential into new categories of service which could be offered via their existing cable plants.

Two major service types have been focused on since that time.

Enhanced video - Examples include:

Pay movie channels; teletext; videotext; interactive services for shopping, banking, etc.; video games; impulse purchase for video, services or goods.

Enhanced network - Examples include: Business data transmission; home security, fire, energy management, utility meter reading, telephone; cable plant management; interface subscribers to network services such as Dow Jones, Source, New York Times, etc.

System control considerations have satisfied basic computer/communications architectural criteria. New complex emerging services are resulting in expanded use of these structures. These factors require the design engineer to revisit basic network design rules and the methods for computer applications within them.

The Designers Tool Kit

The Cable Television design engineer has a more complex problem today than ever before. In new builds: Whats the most effective implementation with future expandability?

In rebuilds: How do we make use of the existing main plant and retrofit new technology to it? To answer these questions we must take stock of the tools at our disposal and various methods for applying them.

Central Equipment - Electronics located at the main operations center (Headend); for signal and data processing.

1) Headend - Various signal processing, encoding, control and transmission equipment.

2) Ancillary Controllers - Mini/micro computer equipment programmed to communicate with and control remote subscriber support electronics.

3) Data Processors - Various computer equipment used to process subscriber or network data; to support customer billing, viewer statistics or provide management reports.

4) Service Processors - Computer equipment used to provide subscriber services (fire, security).

Network Equipment - Electronics located at various points within the network; used for either signal or data processing.

1) Distribution Electronics - Amplifiers, taps, splitters, power supplies, etc., used to provide quality signals throughout the network (may be active or passive).

2) Hub Equipment - May include combinations of central equipment, network distribution and customer support of electronics.

Customer Support Equipment - Electronics located near or within the subscribers premises and which serves as the user interface to the network.

1) Converter Devices - Signal processing and/or digital control equipment which outputs appropriate T.V. signals.

2) Service Devices - Security, fire, energy management or interactive devices which support enhanced services and interface to network equipment.

3) Remote Controllers - Mini/micro computer equipment and/or any combination of converter or service devices; used to centralize functions, access and provide enhanced network operations.

Applications/Methods - To build an effective/expandable cable system architecture we must view the design problem in a layered approach. There are three major layers: Local distribution, plant distribution and network control, each layer has multiple secondary layers.

1) Network Control - The combined effect resulting from central computer to remote customer support equipment interactions. This layer is the most complex in the system design; depending on selected control methods it will exert major influence on both the local and plant distribution scheme. The over-riding concern in network control is to minimize message traffic congestion while reliably servicing all active terminations. Architecturally this leads to a decision on whether the control will be centralized or decentralized. Once this decision is made, options for operational control, device protocol, interfacing to customer support equipment and external environments can be selected.

2) Local Distribution - Connectivity from the main plant system to a subscribers premises. Two options exist: 1) Plant extension via main plant tapping or a loop through cable. 2) Plant extension via star (point-point) distribution; with supportive electronic devices for both options. Having selected the Network Control scheme to be used the decision on which option to use is relatively straight forward. The greater the requirement for enhanced services and their resultant increase in message traffic, the more applicable a star distribution becomes.

3) Plant Distribution - Connectivity from main signal source equipment to local distribution. Plant trunk cable and electronics options exist to provide quality signal source in varying applications; requirements are driven by local distribution interconnection parameters.

Centralized control methods are pervasive in today's cable television equipment marketplace; this is an outgrowth of continued development efforts which began in the early 70's. At that time, computer networks accessed terminals sequentially (polled) for information interchange. Industry vendors applied this technique in their systems to control rising concerns in service theft. The headend-located controller maintains an active device list and associated authorization data which is continually transmitted to remote devices. Early systems were extremely vulnerable to controller failures but are becoming more reliable with the remote terminals which retain program authorizations if the central controller fails. Even with their increased reliability centralized systems do not readily lend themselves to future evolution to support emerging services. This is due to their inherent requirement for transaction/control data to be funneled through the central controller.

Decentralized control is now making its way into the cable television equipment marketplace. This is resulting from applying computer/communications industry networking concepts to the CATV plant. The best current example is inclusion of non-volitile memory in centralized systems as an improvement to converter and system reliability; this is the essence of decentralization. However, when the remote equipment is sufficiently intelligent to control access and retain authorization without central controller interactions then why continue polling them? Following this through further, remote subscriber support equipment can be designed to have certain functions currently housed within the central controller. Further, new functions can be added to remote equipment which enables communications for emerging services.

## Emerging Cable Television Systems Architecture

The elements at work in our technological evolution are:

1) Computers and communications for control and to support services.

2) Services to make new uses of the cable plant and increase per-subscriber revenue on multiple service levels.

3) Existing technology which we must accomodate until it has exceeded its useful life.

4) Equipment availability for production models which incorporate enabling technology.

As we have seen in our own industry as well as automotive, petroleum and many others, only an approach which embraces old methods while evolving to new ones can be successful. While it is feasible to implement a fully decentralized switched cable television system today most applications have existing technological constraints; only new builds can be designed with the most advanced techniques throughout. On the other hand, we must begin to evolve toward network structures which are expandable to meet the demands we already see on our horizon.

Currently, the major network component being developed by numerous cable industry suppliers is the remote controller device. Both on and off premises devices are taking on a Controller versus Converter profile: Digital electronic control, one/two way communications, local authorizations, impulse purchase and support for other emerging services. In their stand-alone application (set-tops) they provide increased reliability and enhanced services. When carried to the next logical step the electronics are housed in a common (Hub) location wherein support becomes less cumbersome. The more expensive electronics are shared by multiple subscribers and ultimate security is attained, without scrambling, because only authorized signals are outputted to subscriber receiving equipment.

Our industry, Cable Television, is entering a period of rebirth. A restructuring is occurring; in the way we operate, the systems which support our business, new programming methods and alternative services. All these focus on one objective: increase the revenue per network termination. With these ambitious goals, we are likely not to see a stabilization in equipment or services but rather a continued evolution to new ways of competing in the communications marketplace. Design engineers must turn to hybrid network implementations which employ advanced technology while accommodating their previous local distribution equipment.

<u>Editor's Note:</u> The author, then with Times-Fiber, completed this presentation too late to be printed in the 1983 NCTA TECHNICAL PAPERS--it is included here with the author's permission and his new address and affiliation.